National
Foreign
Assessment
Center

Secret

25X1

The Status of Science and Technology in China's Modernization Effort

25X1

An Intelligence Assessment

Secret

SW 81-10080
August 1981

Copy 411

Page Denied

National Foreign Assessment Center

Secret [redacted] 25X1

The Status of Science and Technology in China's Modernization Effort [redacted] 25X1

An Intelligence Assessment

Information available as of 20 July 1981 has been used in the preparation of this report.

25X1

This paper was prepared by [redacted] 25X1
[redacted] OSWR also contributed. Comments and queries are welcome and may be directed to the Chief, China Science and Technology Branch, OSWR, [redacted] 25X1 25X1

This paper has been coordinated with the Offices of Economic Research, Geographic and Societal Research, and Political Analysis; the Directorate of Operations; and the Acting National Intelligence Officer for East Asia. [redacted] 25X1

Secret
SW 81-10080
August 1981

The Status of Science and Technology in China's Modernization Effort

25X1

Overview

Efforts to use science and technology to serve the needs of China's "four modernizations" program have been constrained by a shortage of qualified personnel, ineffective management, and the continued inability to translate research findings into production results efficiently. Some of these problems derive from the continued aftereffects of the Cultural Revolution on Chinese research and educational institutions. Generally, however, most of the problems are caused by shortcomings within the institutional structure for formulating and implementing S&T policies. Although substantial progress has been made in remedying a variety of deficiencies, we believe that China's attainment of its modernization goals will be substantially delayed, primarily by limitations in manufacturing technology and modern plant facilities. 25X1

In the materials and electronics industries, for example, sophisticated products can be developed within the laboratory or produced on a prototype basis, but the Chinese have been unable consistently to integrate R&D advances into serial production. Lack of quality control and industrial standardization are also major obstacles; erratic standards and inconsistent quality continue to reduce the compatibility and reliability of communications equipment and computers. Where large-scale, high-volume production is not a main objective, as in China's space program, the major weakness is a poor understanding of systems management concepts and techniques. In the telecommunications network, excessive dependence on local initiative and self-reliance, instead of centralized coordination and control, has resulted in a patchwork pattern of technology. 25X1

China's leaders, aware of these problems and that modernization must be more gradual than originally anticipated, have greatly restructured the modernization program. Development of technologies for light industry, agriculture, and energy will be given priority. This change in approach and several successful cases of indigenous S&T development lead us to conclude that the system is potentially capable of functioning effectively and of supporting the revised needs of the modernization program in selected areas. 25X1

Initial plans for upgrading domestic S&T capabilities and reforming the S&T system were to be achieved by decentralizing decisionmaking and increasing the autonomy of the operating unit. Some of these reforms have been postponed by the imperatives of economic readjustment. Various centralized controls have been reasserted in selected areas to ensure that

research activities make a more direct contribution to the modernization program. The initial goal of modernizing all domestic S&T capabilities has given way to increased emphasis on applied R&D. Budgets for basic research programs—such as high-energy physics—have been cut so that the limited financial resources can be given to production-related activities. [redacted] 25X1

Scientists have been given a greater role in S&T policymaking to reduce inefficiency and to ensure that modernization projects meet acceptable scientific criteria. During the Cultural Revolution, people were placed in key S&T positions on the basis of their political credentials rather than their technical qualifications. Problems still exist in trying to replace these personnel with more competent individuals. Efforts have also been made to place younger, well-qualified people in positions of authority within educational and research organizations. [redacted] 25X1

Large numbers of students and researchers have been sent overseas for advanced training, while domestic educational programs are being strengthened. Despite some success in improving personnel allocation and training, however, the dearth of qualified technicians and scientists in China probably will continue to be a serious constraint on the modernization drive well into the 1990s [redacted] 25X1

A variety of economic and financial factors also will have a major impact on the modernization program, particularly with respect to the importation of foreign technology. [redacted] 25X1 25X1 While China's top leaders have shown more willingness to rely on foreign technologies to support modernization, the acquisition of foreign technology and equipment has not, in many cases, produced the desired results. Emphasis has been shifted, therefore, from purchasing whole plants and equipment to renovating and rehabilitating existing enterprises. A greater effort will be made to secure technologies more appropriate to China's large labor force and inadequate energy output. Technology imports once again will be closely reviewed by the central economic authorities to ensure a better match between foreign purchases, local needs, and resource availabilities. [redacted] 25X1

25X1

A shortage of foreign exchange also will continue to restrict China's ability to import foreign technology, particularly since the Chinese remain reluctant to incur high levels of foreign debt, except at concessionary rates. Initially, China had hoped to finance much of its technology imports through expansion of petroleum exports. This has not proven feasible in view of the continued technical constraints inhibiting rapid expansion of petroleum production. In addition, modernization has led to increased energy consumption in China, further reducing the availability of petroleum for export. 25X1

Finally politics promise to continue to influence in the modernization program. Because policy was reversed frequently in the past, many S&T personnel are skeptical about becoming fully committed to the new policies, and political concerns have made many scientists reluctant to take the initiative to start new projects or introduce major technical innovations. Many of the country's leaders remain concerned about the long-term cultural and political impact of foreign ideas and technology on Chinese society. In any case, the success of the modernization program in general, and the modernization of science and technology in particular, will depend upon the maintenance of a political consensus supporting the primacy of the economic objective. Even if China can remedy its technical deficiencies, the effort to advance S&T capabilities in areas relevant to modernization will fall significantly short of its goals without political stability.

25X1

25X1

Contents

Approved For Release 2007/08/08 : CIA-RDP83B00551R000200150005-7

[redacted] 25X1

The Status of Science and Technology in China's Modernization Effort [redacted]

25X1

Preface

Since the mid-1970s, China has been engaged in a major modernization program designed to enhance national security while promoting long-term self-reliance. The roots of the program, known as the "four modernizations," date back to former Premier Zhou Enlai's 1975 address to the Fourth National People's Congress. The program gained full momentum in late 1976 after the death of Communist Party Chairman Mao Zedong and the arrest of the radical "Gang of Four." Program objectives, as stated by the Chinese, were to upgrade agriculture, industry, national defense, and science—including technology capabilities—to advanced world levels by the year 2000. This paper will assess the status of science and technology in China's modernization program, including Chinese S&T capabilities and the performance of China's R&D system. [redacted] 25X1

[redacted] 25X1

The Status of Science and Technology in China's Modernization Effort [redacted] 25X1

Background

China's "Four Modernizations" Program

Since the mid-1970s, China has been engaged in a major modernization program designed to enhance national security while promoting long-term self-reliance. The roots of the program, known as the "four modernizations," date back to former Premier Zhou Enlai's 1975 address to the Fourth National People's Congress. The program gained full momentum in late 1976 after the death of Communist Party Chairman Mao Zedong and the arrest of the radical Gang of Four. [redacted]

Program objectives, as stated by the Chinese, were to upgrade agriculture, industry, national defense, and science—including technology capabilities—to advanced world levels by the year 2000. In February 1978, a set of modernization goals were spelled out that included construction of 120 large-scale industrial projects and ambitious production targets for steel and agriculture. Recognizing the backwardness of their industrial and S&T base, the Chinese showed a greater willingness to import foreign technologies and to engage in international commerce. Reform of the existing system of management in industry, education, and research was also stated as a primary goal. Without such a comprehensive modernization program, its supporters argued, China would remain weak and vulnerable. [redacted]

Initiation of the growth-oriented modernization program revealed that the Maoist approach of giving primacy to political values had been relegated to secondary importance. Generally speaking, policies in effect during the Maoist era had greater social equity as their primary goal. This emphasis on egalitarianism implied acceptance of a slower growth rate for the national economy in the hope of alleviating three major areas of inequality in Chinese society: the urban versus rural sectors, industry versus agriculture, and intellectual versus manual labor. In contrast, the "four modernizations" program was an attempt to speed up economic development to improve more rapidly the people's livelihood and to strengthen national economic, defense, and technological capabilities. [redacted] 25X1

By early 1979 Chinese leaders realized that their initial goals for modernization were overly ambitious, that the details for implementing the program had been obscure, and that the priorities for allocating scarce financial and technical resources were loosely defined, at best. Although China had begun extensive purchases of foreign technology and equipment in 1978, economic limitations and a lack of qualified technical personnel soon impinged upon the country's ability to acquire and to absorb imported technology for its modernization program. Other bottlenecks, such as an underdeveloped and poorly distributed transportation system, insufficient energy supplies, and a lack of coordination among relevant organizations also helped to slow the pace of modernization. The Chinese leaders' recognition of these problems—a necessary step in any attempt to develop appropriate solutions—led to formulation and implementation of a readjustment program in early 1979. In this program, the Chinese leadership gave increased emphasis to agriculture and light industry and scaled down many of the goals and projects in the original modernization plan. [redacted] 25X1

25X1 25X1

The full extent of China's problems, however, became apparent during late 1980. Efforts to readjust the modernization program were meeting only limited success, and the imperatives of readjustment were clearly in conflict with ongoing efforts in economic reform. In particular, the Chinese leadership recognized that economic readjustment required increased control by the central political authorities to ensure adherence to new policies and guidelines; economic reforms, which were aimed at decentralizing economic decisionmaking and management to stimulate local initiative, had resulted in deviations from the goals of readjustment. Domestic problems including a growing budget deficit and rising inflation were

among several factors that forced cancellation or postponement of several major development projects, including the highly touted Baoshan steel mill and the Dexing copper mine. Severe limitations were placed upon future capital construction, and work on several large petrochemicals projects was suspended indefinitely as the result of economic cutbacks and inadequate supplies of feedstocks and raw materials to run the plants. [redacted]

By the end of 1980, the momentum and optimism characterizing the modernization program at its inception had been lost. As the result of a party work conference in December 1980, China's top leaders codified their readjustment program and continued the long process of realigning their priorities. The leadership began to scale down their goals still further to better reflect financial, personnel, and resources limitations. Efforts to ensure adherence to the various elements of the readjustment program continued throughout the first half of 1981. [redacted]

Modernization of Science and Technology

Throughout the course of the modernization program, science and technology have continued to be high-priority items as far as the investment of financial and personnel resources is concerned. Closing the technology gap between China and the West and overcoming the obstacles to greater technological self-reliance are the two dominant goals underlying current S&T policy. The Chinese consider S&T modernization to be a necessary prerequisite to the successful completion of the three other areas covered by the "four modernizations" movement: agriculture, industry, and national defense. [redacted]

In March 1978 the Chinese announced a comprehensive national S&T plan. This provided the basic blueprint for the S&T modernization, and delineated eight areas where S&T efforts were to be concentrated: agriculture, energy, materials, electronics, lasers, space, high-energy physics, and genetic engineering. Some fields were chosen because they had the potential to contribute to the modernization program, others because key S&T leaders desired to use basic research as a means to reintegrate Chinese scientists into the world's scientific community. [redacted]

The decision to undertake such a comprehensive S&T modernization program must be viewed within the context of lingering effects of the Cultural Revolution on the Chinese scientific community and educational institutions. The Cultural Revolution in the late 1960s was a political movement in China, designed to promote radical egalitarian Maoist goals. It had a devastating effect on scientific research and training in China: both virtually ceased for almost 10 years. [redacted] 25X1

25X1

Although the direct impact of the Cultural Revolution varied considerably from one institute to another—depending on the protection afforded by the political leadership and the visibility of the institute and its members—most were disrupted to some extent. Scientists were ridiculed for their "elitist" attitudes. Foreign-trained Chinese scientists were suspected of treason; many were sent to work in factories or on farms. Some scientists committed suicide or were physically abused. China's scientific community was isolated from the research of other countries. Moreover, Chinese scientists were prevented from continuing their own research in China. [redacted] 25X1 25X1

The radicalism of the Cultural Revolution and the Gang of Four reinforced the tendency of both Chinese S&T institutes and individual scientists to remain isolated from each other; scientists were instructed to learn from peasants and workers rather than from each other. As the last vestiges of the Cultural Revolution were removed from the Chinese political scene, lack of communication remained a major obstacle to S&T modernization. [redacted] 25X1

25X1

The Cultural Revolution had a less evident but perhaps more pervasive influence on the attitudes of the Chinese population, in general, and the intellectuals, in particular. Since then, many S&T personnel have taken a very cautious approach toward the current changes in priorities. A large number have been reluctant to become fully committed to new projects and policies. This has created a sluggishness in research and production, because many scientists have been unwilling to take the necessary initiative to launch new projects or to accept the responsibility for overseeing those already in existence. [redacted] 25X1

25X1

The scientific stagnation left China's S&T capabilities 10 to 20 years behind advanced, modern levels. To revitalize their S&T system and to stimulate scientific advancement, Chinese leaders decided to send large numbers of graduate students and scientists abroad for advanced technical training. Chinese universities reintroduced scientific curricula. Scientific personnel were given increased responsibilities in economic organizations, as well as those for research and development. Chinese leaders encouraged the acquisition of foreign technology as a means of remedying S&T deficiencies. By foregoing the more gradual approach of developing technologies indigenously, the leaders believed that foreign technology and training could become the foundation for closing the S&T gap between China and the advanced nations by the year 2000. [redacted]

Revision of China's basic modernization plan in 1979, however, forced the leadership to reassess its S&T modernization strategy. As a result, Chinese leaders gave increased attention to areas with near-term practical applications. They issued a revised list of priority areas: agriculture, energy, materials, communications, electronics, and space. In most cases, the selected areas constituted critical bottlenecks in the modernization program. More importantly, the Chinese leaders began to recognize that advanced S&T alone were not the solution to China's problems. Other more fundamental stumblingblocks stood in the way of both economic and S&T modernization, including managerial, attitudinal, organizational, and financial problems. [redacted]

By the beginning of 1981, the imperatives of economic readjustment resulted in further changes in China's S&T strategy—the foremost being the postponement and in some cases, the cancellation of several major development projects involving large inputs of foreign technology and technical assistance. Above all, economic and financial considerations forced the Chinese to become more selective in their technology acquisition. The emphasis on purchasing whole plants and equipment that formerly was characteristic of the initial phase of S&T modernization has been altered. [redacted]

Today, greater emphasis is being given to the renovation of existing plants and equipment. Current policy is to purchase from abroad only those technologies the Chinese cannot develop quickly enough themselves and only the technologies they can rapidly absorb. China's top economic administrators have given instructions that all available versions of technology must be thoroughly investigated before a purchase will be approved. Particular emphasis will be given to technologies applicable to agriculture, light industry, and energy, as well as technologies characterized by high labor intensity and low energy consumption. [redacted]

25X1

The Chinese leadership has again altered research priorities and policies. The original goal of modernizing the complete spectrum of China's S&T institutions now reflects even greater emphasis on applied research. Most S&T projects must produce economic benefits and must make tangible contributions to the modernization program. Technological choices are to be based upon local needs and capabilities, rather than upon purchasing the most up-to-date technologies. These new policies are designed to further reduce waste of material and financial resources, a problem since the outset of the modernization program. [redacted]

25X1

25X1

Although the S&T modernization program has faced cutbacks, the cutbacks are less severe than in other parts of the readjustment program and reflect greater emphasis on applied research. The decision in early 1981 to postpone indefinitely a major project on high-energy physics confirms this new policy orientation away from basic research. [redacted]

25X1
25X1

Politics, Modernization, and S&T Policy

Despite the spectacular reversals in various policy areas since the death of Mao, both the party and state bureaucracy apparently are not easily malleable. Some S&T administrators—many of whom rose to positions of authority during the Cultural Revolution—have a vested interest in maintaining their positions. Large numbers of such individuals are still in place. These well-established bureaucrats are resisting efforts to disengage politics from science. [redacted]

25X1
25X1

As a result, foot-dragging and incompetence continue to plague Chinese attempts to remold the S&T system. Realizing these problems, the Chinese leadership is attempting at both the national and local levels to replace and retrain officials who fail to support wholeheartedly Deng's modernization program. Deng and his supporters probably will succeed in overcoming this opposition. Some progress has already been made in replacing these individuals as evidenced in the recent elections held at the Chinese Academy of Sciences in May-June 1981. Extensive reforms, however, will be slow and eventually may impinge adversely upon China's ability to modernize S&T.

The extent to which the country should import foreign technologies continues to be the subject of an ongoing political debate in China. Some officials fear that overreliance on foreign technology will seriously disrupt Chinese society, adding stresses to the political system and increasing dependence—real or perceived—upon other countries for training, and for technical and financial assistance. In particular, these people are concerned over debasement of Chinese capabilities by those who have developed an admiration for Western scientific and technological progress. How much of the Chinese "essence" the leadership can safely sacrifice to accommodate the imperatives of obtaining desperately needed foreign technology and managerial and organizational assistance will be a focal point of political debate in the 1980s. We believe the Chinese will continue to encounter difficulties in arriving at a technologically appropriate and politically acceptable balance between self-reliance, selective borrowing, and outright dependency.

China has been contemplating the issue of how to utilize Western technology for over 100 years. Finding a workable solution to this question has become politically imperative. Throughout 1979-81, the Chinese press published numerous articles defending the import of foreign technologies and the use of foreign advisers during the 19th century, implying that there is still some opposition to similar programs today. These articles also have stressed that China must be more selective in its efforts to acquire foreign technology. Similar concern exists about the long-term effects of foreign ideas from movies, advertising, and books upon China's social order. If opposition to such "social pollution" grows, participation by foreigners or introduction of foreign technology into the modernization program will become increasingly difficult.

25X1

Some observers also have commented that the "rush" to modernize S&T in China in the late 1970s has led to additional political problems and pressures. The case of the Baoshan steel mill, a large-scale capital construction project involving West German, Japanese, and US participation, is illustrative. In September 1979, a high-ranking Chinese official admitted that although the Baoshan project was ill-conceived, it continued to receive support from the leadership, because it had been set up as a premier part of the modernization program. A number of technical mistakes resulted in wasting large amounts of foreign exchange. The site of the Baoshan project was unsuitable from an engineering standpoint. In addition, large ore carriers cannot berth nearby, making it difficult to supply the mill with needed raw materials. Although considerable expense might have been saved by reassigning technicians from the Anshan steel complex to build the plant, regional political rivalries between North and South, and Shanghai's desire for a more modern plant than Anshan—and not technical feasibility—led to the decision to undertake the project. In late 1980—because of the large costs, the imperatives of modernization readjustment, and continued political criticism—China was forced to postpone construction plans for phase two of the project and has suspended almost all work in phase one. Although the Chinese have reiterated their intention to proceed with phase one, final completion will be substantially delayed until the technical problems can be sorted out. A few Chinese leaders have placed part of the blame for the project's problems on Japan, claiming that the Japanese gave China unsound advice regarding the feasibility of the Baoshan mill.

25X1

25X1

25X1

Political pressures stemming from the rush to modernize also caused key decisionmakers striving to attain production objectives to forgo safety measures and proper maintenance procedures. As in the past, the Chinese have tended to neglect such considerations. Between 1975 and 1980 the Chinese press reported about 1,000 accidents associated with the

operations of the Oceanic Petroleum Exploration Bureau. One widely publicized incident—among several recently in the Chinese press—occurred on 25 November 1979, when the Bohai Number 2 oil rig collapsed and 72 lives were lost. The media recently acknowledged that the Bohai team leader had submitted three separate warnings to the Ministry of Petroleum concerning the safety of the rig. Apparently, because of the pressures to continue and to complete the operation, the Ministry—already under fire for its poor handling of China's petroleum development—ignored these warnings. On 26 August 1980, the Minister of Petroleum Industry, Song Zhenming, was replaced because of the Bohai accident. [redacted]

The Role of Economics in China's S&T Modernization

Economic factors—primarily a shortage of investment capital and foreign exchange, as well as inflation—constitute serious constraints on Chinese S&T development. A major problem plaguing the modernization program since its inception has been that the Chinese have attempted to do too much too fast. Major budget deficits have resulted. Political and economic leaders apparently did not perceive the actual costs of the program. [redacted]

Because the Chinese initially had hoped to finance a large portion of their modernization program through the rapid expansion of petroleum exports, offshore petroleum development was given a high priority. By late 1980, however, it appeared that exploitation of both onshore and offshore areas would be much more gradual than originally anticipated and that expansion of oil exports would be limited at least until 1985. The increasing energy requirements of the modernization program further reduced the likelihood that China would be able to rely on petroleum exports to finance the purchase of foreign technology. [redacted]

To remedy financial shortfalls, the Chinese recently have shown a greater willingness to borrow needed funds from abroad, although only at concessionary rates. In early 1980, China and Japan signed a major loan agreement to help finance the construction of six major projects related to energy development. The Chinese have been offered additional loans and credits for projects from several countries, although they have yet to take advantage of these offers. China has joined the World Bank and the International Monetary Fund, and has secured development-related assistance from both organizations. The Chinese hope to use World Bank assistance to upgrade the domestic education system and to finance additional hydropower development projects. International Monetary Fund assistance has been used to help manage the country's balance-of-payments problems. The Chinese also have held discussions with the United States regarding financing from the Export-Import Bank, 25X1
and in May 1981 signed two agreements, a memorandum of understanding on financing procedures and a loan agreement. [redacted] 25X1

The Chinese have promulgated a new foreign investment law to help alleviate some of their financial problems by promoting joint ventures (equity and nonequity) between foreign firms and the Chinese Government. A structure to promote compensation agreements, whereby a foreign partner receives a portion of the output in return for bringing technology and equipment to China, also has been developed. Because of considerations such as political stability, 25X1
economic performance, and the overall vagueness of the legal and financial aspects of Chinese law, many foreign investors have been reluctant to undertake projects. Domestically, the rapid expansion of equity-based joint ventures has been the target of some opposition, thus further delaying the expansion of these ventures. In the future, the framework of joint ventures, however, may be the only viable means for China to secure foreign technology and to finance badly needed projects. [redacted] 25X1

In the final analysis, the Chinese leadership still remains apprehensive about expanding greatly the 25X1
extent of their external debt. A major factor behind 25X1
Chinese thinking has been the country's experiences with the Soviet Union in the 1950s and the Western nations in the early 1970s, which were criticized for both economic and political reasons. Thus, the Chinese remain concerned about the potential costs of becoming overly dependent on external sources for financing modernization. [redacted] 25X1

Major questions of economic priorities have influenced the course of S&T modernization. Policy disputes revolving around the issue of greater decentralization of decisionmaking, for example, have served to leave the lines of authority only vaguely defined. In many cases, the Chinese bureaucracy has been unable to formulate clearly stated policies. Even when policies have been announced, the bureaucracy has lacked the capabilities and authority to implement them. Economic decisions and foreign technology purchases have been made without adequately considering the availability of critical inputs and resources. The current program of economic readjustment has been designed to remedy some of these problems. For example, all large foreign technology purchases will be more closely scrutinized; strict controls have been placed on the allocation of foreign exchange to avoid purchases without the approval of the control authorities. Financial scarcity and bureaucratic obstacles, however, will continue to slow significantly the pace of the entire modernization effort. [redacted] 25X1

The Manpower Requirements of S&T Modernization

A shortage of qualified technical personnel is another major constraint. As a result of the political turmoil created by the Cultural Revolution, China's major educational institutions were closed, and most of the facilities that trained young people in fields such as engineering and natural science were shut down for almost 10 years. In 1978, China's State Science and Technology Commission (SSTC) conducted a nationwide survey to obtain statistics on the number and qualifications of technical and scientific personnel. This survey revealed that an inadequate number of qualified personnel is China's most serious problem. Among S&T personnel who have had high-quality formal training in China or overseas, many are old and incapable of exercising a direct role in the day-to-day operations of active research laboratories. These inadequacies have created a serious strain on China's S&T personnel resources, because the Chinese have yet to develop a successful strategy for the effective and efficient use of their limited number of qualified personnel. [redacted] 25X1

China's S&T community can be divided into four basic groups or "generations," with varying degrees of expertise and training. The first group is comprised of personnel who were trained in Western universities and returned to China at the time of the Communist takeover. With an average age over 60, these people are steadily decreasing in number. [redacted] 25X1

The second group includes personnel trained in China or the Soviet Union during the 1950s and early 1960s. These people, who are in their forties and fifties, have had very specialized training and remain conditioned to working in a Soviet-style work environment—one in which a worker is given little incentive to pursue innovative ideas and projects. Because they have had some technical training, however, the majority of the students and scholars selected for the initial overseas study program in the late 1970s came from this group. [redacted] 25X1

Most of the third group are technical personnel and political workers appointed to S&T jobs immediately after the Cultural Revolution. This group includes the first people to receive formal education after the interruptions of the Cultural Revolution. Although a sizable number now hold positions in Chinese research institutions, members of the group lack the background and technical training to spearhead the sustained modernization program planned by the Chinese leadership. Many obtained their positions or entered higher education only by virtue of their political credentials. [redacted] 25X1

The fourth group is comprised of people being trained within rehabilitated Chinese universities. Some eventually will be sent overseas for advanced training, once they complete their undergraduate training in China. This group constitutes the country's main hope for meeting the technical demands of the modernization program. In 1981 Chinese universities will graduate the first class to have entered higher education after the fall of the Gang of Four. Although the quality of university students has begun to improve, it is still too early to evaluate their full technical competence. [redacted] 25X1

The Chinese education system must be greatly improved and expanded before it can produce an adequate number of qualified persons to fill key positions in research organizations and institutions of higher education. A major question still to be resolved is whether the existing well-trained cadre should be used in a teaching or research capacity or should be sent overseas for advanced education. Until this issue is settled and more competent teachers can be trained, the goal of effecting an almost threefold increase in the number of scientists—to 800,000 by 1985—which was announced in the 1978 S&T modernization plan, appears impossible to achieve. Currently, only 3 percent of all high school graduates (approximately 270,000 in 1980) can receive higher education, an inadequate number in view of China's pressing needs for qualified scientists and technicians. Any inability to alleviate the current shortage of qualified S&T personnel will affect detrimentally the pace of China's modernization program.

Extensive efforts have been made to move younger persons into positions of authority within both research and education institutions. For example, during the May 1981 meeting of the Chinese Academy of Sciences, younger scientists were elected to key decisionmaking offices to ease the transition to a new Academy of Sciences leadership in the future. Bottlenecks in replacement of older or less qualified persons in the S&T system, however, are still prevalent. Promotion on seniority only is very common. These problems—unless quickly rectified—also will reduce the likelihood of China's meeting its modernization goals by the year 2000.

Modernization in Key S&T Areas

This section of the paper will focus on six key fields in which S&T modernization has been actively pursued. In many respects, Chinese successes and problems are representative of the situation in other fields. Each area is analyzed from the perspective of development priorities established by the Chinese leadership.

The major point emerging from this analysis is that the key to the Chinese S&T modernization drive lies not merely in acquisition or development of state-of-the-art technologies but also an adequate S&T infrastructure and pool of qualified S&T personnel to fully utilize existing resources and to effectively assimilate foreign technology. This is true in both the civilian and military sectors. The major constraints on S&T modernization in each area result from ineffective management, a continued inability to clearly define priorities, and a lack of institutionalized channels to effectively translate research findings into actual production results. Current Chinese efforts to remedy these problems have led to isolated examples of research and development successes, but as a whole, the system remains caught in a web of bureaucratic inertia. During the past few years, China has expanded its understanding of the country's primary S&T-related deficiencies. In addition, the Chinese also have increased their knowledge of the international technology market and alternative technology suppliers. These efforts, however, will have little impact on the modernization program until existing constraints—technical and organizational—can be overcome.

25X1

25X1

Agriculture

China's basic goal in agricultural modernization is to increase the country's food supply so that its growing population can be fed. Chinese agricultural modernization is aimed at improved crop varieties, plant protection, fertilizer and agricultural chemicals, irrigation and water management, farming methods and management, and mechanization. Advances in most of these areas have contributed to increased Chinese agricultural production during the past 10 years, but the Chinese recognize that achieving modernization goals will require still further improvements in agriculture, including the adoption of foreign technology.

25X1

25X1

Considerable disagreement has existed as to whether priority should be placed on biological or mechanization technology. Some leading Chinese experts hold that scientific research on improved plant varieties, fertilizers, and pesticides, as well as improved irrigation, should be emphasized first, with mechanization a longer term goal. The scientists point out that emphasis on multiple-cropping requires planting early maturing varieties and using more organic and chemical fertilizers for the two or three crops per year.

25X1

25X1

Other experts favor giving priority to mechanization of agricultural processes (cultivating, intertilling, harvesting, drying, storage, weeding, and application of fertilizers and pesticides, with less emphasis on agricultural research and chemicals). These scientists note that multiple-cropping requires more frequent planting and harvesting, which could be done more efficiently by machines. They also cite as the benefits of mechanization—timeliness of farm operations, quick turnaround time in multiple-cropping, reduced grain losses through machine harvesting and drying, and reduction of draft animal population (thereby increasing meat production).

That unemployment would be a major drawback to extensive farm mechanization, however, is commonly recognized in China. Unemployment is already a major problem that no one wants to exacerbate. According to present Chinese thinking, increased mechanization will be considered only for planting and harvesting; other operations will continue to be done by hand.

That mechanization cannot be effective without increased yields also is recognized. Larger yields require, in turn, improved crop varieties, extensive application of fertilizer, and water availability. The Chinese are beginning to adopt features of Japanese agricultural modernization, which began with increased use of chemical fertilizers and high-yielding varieties of seed, as well as improved irrigation. The Japanese developed and used mechanized equipment, specially tailored to Japan's agricultural endowments. Recently, Japan has provided China with agricultural chemicals, farm machinery, and other agricultural inputs. Numerous science and technology exchanges between the two countries have facilitated Chinese understanding of the pitfalls of expanding the scope of mechanization too rapidly.

Areas of particular interest to the Chinese are plant breeding for crop resistance, crop physiology research, and experimental design and analysis of research. Because more scientists qualified in these areas are drastically needed, China is exchanging scientists and training Chinese students under agricultural S&T agreements with the United States and other countries. With the recently increased emphasis on agriculture, even more scientists and students will be sent abroad for training.

At the national level, the Chinese are pursuing the acquisition of germ plasm as genetic sources of disease- and pest-resistance for major crops and as a means to broaden the available genetic base of Chinese plant breeding. This research is being done in the Beijing research institute for crop germ plasm under the Academy of Agriculture and Forestry. The Chinese learned the value of germ plasm when they developed hybrid rice varieties, largely at the Hunan rice research institute, using restorer lines of high-yielding semidwarf varieties developed in the Philippines. These areas of research—as well as biological fixation of nitrogen and enhancement of photosynthetic efficiency—must be further developed as a foundation for all agricultural research and are being pursued by Chinese scholars taking advanced training in the United States.

25X1

25X1

China's purchases of foreign agricultural machinery can be expected to increase as agricultural modernization plans are implemented. Equipment purchases, however, will be constrained by unemployment considerations and by China's small plots and terraced fields that restrict the amounts and types of equipment that can be useful. Only on large plains—as in northeast China—can the Chinese apply the large-scale mechanized farming methods of the West.

25X1

25X1

In their farm tests of specialized US equipment for subsoiling, agricultural chemical application, mechanized seed production, and grain drying, the Chinese already have found that using such equipment increases yields. They also have discovered that irrigation technology—using pumps, metering equipment, and center-pivot sprinklers—is valuable because it saves substantial amounts of not only water but also the land that would be occupied by surface irrigation systems.

25X1

25X1

The Chinese want to expand sprinkler irrigation. For now, however, they are holding up large purchases of this and other types of farm equipment while they ascertain the merit of investing scarce foreign exchange. Similarly, they are refraining from purchasing foreign agricultural chemicals and production technologies to minimize dependence on foreign sources and to strengthen domestic production and research capabilities.

25X1

25X1

Energy Production and Transmission

China's severe shortage of electric power is a major obstacle to modernization. Without power, new factories cannot start up and existing factories cannot operate on a irregular schedule. [redacted]

The Chinese estimate that 20 to 30 percent of their existing industrial capacity cannot be utilized because of power shortages. These are caused by poor planning and outmoded technologies in every aspect of power generation—from location and development of primary energy sources, through energy utilization in power stations, to the transmission of electricity. Operation of the Wuhan steel mill in Hebei has been adversely affected by such problems. Despite their ambitious plans for the mill, the Chinese discovered that the electricity in Hebei was insufficient to operate the plant at projected capacity [redacted]

Very much aware of the importance of energy, the Chinese have given energy development plans top priority. They intend to rely on coal as the main source of energy, because they know they have vast supplies. In 1980 approximately 71 percent of China's energy was produced from coal. The Chinese also plan to tap their hydropower resources—the largest in the world. But because the major rivers are located in southwest China—a long distance from Chinese industrial areas—the Chinese will require high-voltage transmission technology, which they do not yet have. [redacted]

Originally, the Chinese regarded oil as a source of foreign exchange to help pay for modernization projects, but this potential became uncertain as the Chinese realized that they would require much more petroleum themselves. (Petroleum accounted for 25 percent of China's energy in 1980.) Moreover, the Chinese do not know the actual extent of their resources and cannot expect to substantially increase oil production before 1985. Inadequate exploration and exploitation technologies will continue to be a major constraint. [redacted]

As a result, the Chinese have given nuclear power greater importance in their long-term energy plans. They realize that nuclear energy could be a good supplement to the energy needs in industrial regions that lack coal or hydropower, because nuclear power plants can be sited where needed [redacted] 25X1

25X1 The complexities involved in developing a nationwide energy system make it difficult to judge when the Chinese will have enough power to meet their modernization needs. These needs and the plans to meet them are changing as the Chinese adjust their overall economic goals and timetables. [redacted] 25X1

The Chinese proposals to develop energy resources are becoming more and more realistic as planners get farther along—realize their past mistakes and anticipate future problems, and modify the plans accordingly. The success of this massive task depends not only upon assimilating the tremendous number of technologies directly involved in locating, extracting, 25X1 and processing energy resources, but also upon developing the industrial infrastructure to produce the machinery needed in these processes—machinery such as mining equipment, drill bits, and turbines. Also needed are important supporting elements, such as railroads to transport coal to power stations. Historically, China has underestimated its needs in developing railroad lines to support energy-related transportation requirements. [redacted] 25X1

As in other areas of modernization, the Chinese do not want merely to buy equipment from abroad. Rather, they prefer to learn how to produce the 25X1 equipment themselves. This requires a large cadre of skilled engineers and technicians, which China does not have. To meet this deficiency, the Chinese are sending scores of people overseas as students to Western universities and as delegations to visit all kinds of energy facilities in an attempt to learn modern technologies. [redacted] 25X1

If China can maintain an even political keel and continue its present emphasis on energy development, we estimate that the modernization plans, the supply of technical manpower, and the industries themselves 25X1 will begin to crystallize and will become coordinated by 1985. Another five years probably will be needed, however, to show concrete results in increased energy supplies. [redacted] 25X1

Coal. Increasing the quantity and quality of coal production has been made even more essential by China's continued reliance on coal as the major domestic source of energy. The Chinese plan—where possible—to convert their boilers from oil to coal. To meet the resulting increased demands for coal, the Chinese need to increase mechanization of their coal-mining processes, including higher capacity and more efficient extraction, loading, processing, and hauling systems. At present, only 30 percent of China's coal comes from fully mechanized operations.

The Chinese should have little difficulty in adapting to the use of modern, high-speed machinery, because they have experience in mechanized, underground mining methods. They may encounter difficulty, however, in designing underground and open-pit surface mines because they are not experienced in designing for high-capacity operations. In order to design mines capable of using modern equipment efficiently, the Chinese will need to improve their drilling and seismic programs so that they can delineate precisely the size and shape of deposits for accurate mine layouts

The Chinese are limited in their capacity to purchase modern mining machinery abroad because of a shortage of foreign exchange and their desire to avoid excessive dependence on foreign sources. China's ultimate goal is to manufacture its own modern mining equipment. This, however, will present a vast array of problems in industrial technology and infrastructure, involving machine design, metallurgy, hydraulics, and quality control.

To meet the demand for better quality, the Chinese need to process more coal. At present, only 10 to 15 percent of their total production is processed; this coal is exported or is used in steel manufacturing. To replace existing methods, China needs modern, high-capacity crushing, sizing, and washing equipment, and the flotation technologies upon which this high-capacity equipment is based.

The most vital problem facing China in obtaining energy from coal is transportation of the coal itself. China's railroads cannot move the coal to power plants as fast as it is mined. As a result, the Chinese lack sufficient electricity to run their electrified trains.

To speed development of its coal industry, China negotiated agreements in 1978 and 1979 with West Germany, France, Great Britain, Japan, Yugoslavia, Romania, and Poland. The Sino-Japanese agreement for coal development is of particular interest, because it includes financing for technology purchases and technical assistance. The Chinese also purchased a wide variety of mining and processing equipment from the United States and other countries—apparently to survey the variety of coal technologies and equipment available and to determine what is most suitable for their purposes.

25X1

25X1

The Chinese have sent numerous delegations to study coal equipment and technologies in foreign countries. Hoping to make sales, these countries have welcomed the Chinese and have reciprocated with coal delegations to China. In general, the exchanges have produced few concrete sales, but the Chinese undoubtedly have benefited from their exposure to modern mining equipment and technologies.

25X1

25X1

The Chinese now are caught up in readjusting their economic priorities and allocations of precious foreign exchange and in determining what kinds of contract conditions would be most beneficial. They have invited several countries to submit proposals for joint ventures, but inasmuch as China has not set definite conditions for these ventures, foreign countries are refraining from definite commitments.

25X1

25X1

Oil. China's modernization program will create demands for increased oil production, not only for domestic needs as energy, lubricants, and feedstocks that will increase as the country becomes more industrialized but also as a source of foreign exchange to help pay for modernization. At this point, however, China is having to reduce its oil exports, because its oil production has leveled off, and its own requirements have increased.

25X1

25X1

The Chinese have done well up to now in locating and extracting oil with the equipment and technologies they possess, but it has been "easy" oil. The Chinese admit they will not be able to increase production with their current equipment and technology.

25X1

25X1

A major Chinese deficiency is outmoded seismic technology that does not provide resolution of sufficient clarity to locate subtle, complex, oil-bearing structures. Further, Chinese seismic data are often poorly processed, making accurate analysis difficult. As a result, China is in desperate need of higher speed computers to process the tremendous volume of seismic data being collected. Another problem is that geophysical data often are not correlated with geological data. As a result, many wells are drilled in poorly selected locations, resulting in substantial misallocations of limited financial and technical resources. Most recently, however, many of these problems have been at least partially alleviated by the technical assistance and data processing provided by foreign firms working both in offshore and inshore areas.

As with many industries in China, an unevenness in technical sophistication exists from place to place. This probably reflects the scarcity of equipment and, more importantly, the shortage of skilled technical personnel; both are distributed unevenly and spread too thin. The resulting disparities are exacerbated by a lack of communication among various oilfields and the Chinese reluctance to deviate from procedures that have been successful in one place but may be unsuitable under different geological conditions.

Drilling rates are slow because the Chinese lack in-depth expertise. For example, they seem not to realize the value of using drilling mud, which is needed to lubricate drill bits and to flush cuttings from drill holes. If the Chinese have mud equipment, they often do not connect it or they operate it improperly. Further, their drilling mud techniques are sometimes so poor as to be almost ineffective.

In-depth expertise also is lacking in China's methods of high-pressure drilling control. If the Chinese have blowout preventers, they often do not install the equipment. They seem not to realize the value of the preventers—that blowouts decrease reservoir pressures and cause delays. In some instances of abnormally long drilling times, where underpowered rigs set up a succession of inefficiencies in the use of drilling tools and hoisting systems, the Chinese lacked the technical knowledge to identify the source of the problems. Relatedly, because the Chinese lack tungsten carbide technology, Chinese-made drill bits wear out quickly, necessitating frequent, time-consuming replacement. 25X1

Initially, the Chinese limited their requests for foreign assistance to exploration techniques for offshore areas. Recently, however, they expanded their aid requests to include onshore areas as well. US, Japanese, French, British, and Dutch companies are conducting seismic surveys off the Chinese coast at their own expense, hoping to be invited to develop what they find. In May 1981 the Japan-China Oil Development Corporation made a significant oil discovery in the Bohai Gulf. The company hopes to begin commercial production by 1986. French and US companies are conducting onshore seismic surveys in far western 25X1 China to delineate more precisely the known oil deposits. The Chinese also have requested French assistance in processing some Chinese seismic data and have explored the possibility of obtaining US computers. 25X1

The Chinese are attempting to acquire foreign oil-extraction technologies. After two years of negotiations, the Chinese signed a contract in mid-1980 that will give them the US design and manufacturing technology they need to produce high-quality drill 25X1 bits. We have some evidence, however, that this contract was canceled when all foreign exchange commitments were reviewed as part of the overall economic readjustment program. If so, the Chinese decision shows that despite its priority, energy is also subject to close, budget-cutting scrutiny. 25X1

Through exchanges of oil delegations and invitations to Western oil companies to conduct symposia in 25X1 China, the Chinese are trying to learn how to improve extraction techniques. The Chinese have asked some foreign oil companies to submit proposals on how China could improve extraction processes—this may be only another step in eliciting free advice, or it may be the basis for signing assistance contracts. 25X1

Electric Power. The shortage of electric power appears to be the result of insufficient capital investment

over the past 10 years, poor management, and outmoded equipment. The Chinese have the basic technologies to manufacture their 1950s-vintage generating and transmission equipment, but they cannot produce enough. They also need modern technologies for equipment to generate and to transmit the higher voltages required by the expanded industry projected under their modernization plan and by the longer transmission distances from remote hydropower sources.

The Chinese need to make advances in power generating equipment. They have designed and manufactured boilers with capacities up to 200 megawatts (MW) and 300 MW, but they need advanced circulation, welding, and refractory technologies if they are to manufacture the 500-MW and 600-MW boilers to produce more electricity. They can mass-produce 200-MW steam generators, but not the necessary 300-MW generators. Chinese delegations studying foreign power systems have expressed interest in US and West European steam turbine technology. They have discussed purchasing one or two coal-fired power plants to serve as prototypes. These projects would be joint ventures or would be placed under licensing agreements to give the Chinese the capability to build their own plants.

In developing hydroelectric power, a major problem for the Chinese has been geologic site surveys of dam foundations. Samples taken to determine quality of the foundation rocks are often fragmented, because the Chinese-made drill bits are inferior, and the Chinese generally are weak in rock mechanics. Their lab tests and analyses of rock samples sometimes produce faulty interpretations, leading to problems in dam design and tunnel construction.

The active hydropower development agreements signed with the United States and Japan call for on-site studies and training of Chinese personnel; rock mechanics have been singled out as an area of particular interest. Chinese delegations have surveyed French, West German, Swedish, US, and Japanese technologies and equipment. Industry representatives from these countries have gone to China to present sales demonstrations of their equipment. Before their concern over foreign exchange caused them to halt foreign contracts, the Chinese—still uncertain about what technology they wanted—were trying to negotiate contracts for Chinese manufacture of equipment. 25X1

To cope with the expanded industry of their modernization program, the Chinese will need at least 500-kilovolt (kV) systems for power transmission. The Chinese do not have the technologies, however, for systems higher than 300 kV, although they have been seeking foreign assistance to develop these capabilities. Their major power grids are 200 kV; they manufacture their own 220-kV transformers, circuit breakers, insulators, switch gear, and other equipment. 25X1 25X1 25X1

The Chinese have one 330-kV line in operation, and they have produced 330-kV transformers. But their technical capability to mass-produce transmission lines at this voltage and tie them into the Chinese power grid appears stretched to the limit. 25X1

Nevertheless, the Chinese are working on 500-kV systems and have successfully trial-produced their first 500-kV transformer, representing a new level of technology in China. Construction has begun on a 500-kV line in northeast China. Much of the necessary equipment will have to be imported because Chinese technology lags in such areas as sulfur-fluoride gaseous insulation, arc-interrupters, circuit breakers, and lightning arresters for 500-kV systems. The Chinese have signed contracts with France and Sweden for suitable equipment and technology. Chinese delegations also have expressed interest in US and Japanese equipment, but they want contracts for complete manufacturing technology rather than just purchase of the items. 25X1 25X1 25X1

Through delegations abroad, the Chinese are acquiring vast amounts of information on power transmission—and they are learning fast. Because of the desperate shortage of trained personnel, however, China will require five to 10 years to diffuse the information to all concerned and to train enough people to design, produce, and use the quantities of equipment required to meet modernization goals. 25X1

Nuclear Power. The Chinese are beginning to realize that nuclear power could supplement the energy needs of industrial areas lacking adequate coal and hydropower resources. In some areas, coal deposits within reasonable distances of existing industrial power grids are insufficient for projected thermal power requirements. As noted, transportation systems would not be able to deliver the necessary quantities of coal, therefore, without extensive expansion. Hydropower resources that could be developed without displacing vast numbers of people and covering valuable agricultural lands lie mainly in the remote southwest. Their location thus presents problems of long-distance, high-voltage power transmission. The Chinese have concluded that nuclear power could provide a solution to these problems, because nuclear plants can be sited near industry, and transportation of nuclear fuel would not impose a burden on the transportation system.

Probably as a result of this realization, China resumed negotiations with France in October 1980 for the purchase of two large pressurized-water power reactors. (These negotiations had been terminated in mid-1979.) Since 1980 provincial authorities in Guangdong Province have been discussing with Hong Kong power authorities a joint project to construct a nuclear power plant in Guangdong that would supply electric power to both Hong Kong and Guangdong. The project would provide training and experience to the Chinese. Indications are that the French reactors will be used. The Chinese claim they would prefer to buy nuclear equipment and technology from the United States, but they do not want to be subjected to safeguard inspections. (France apparently is less concerned with imposing strict monitoring and inspection procedures.) If the Chinese go ahead immediately with the Guangdong project, the power station cannot become operational until the late 1980s.

China has not made a firm decision to purchase foreign reactors. Quite probably, such a decision has been delayed, because it is tied to reappraisals of the large, expensive projects during the economic readjustment.

Like other countries contemplating nuclear power, China has stirred controversy and bureaucratic power struggles in its recent steps toward nuclear power. Some Chinese scientists are concerned over safety aspects, some economists think nuclear power is too costly, and some bureaucrats are concerned about foreign interference from safeguard inspections and a possible increased dependence upon foreign technology. The ministries of coal, petroleum, and electric power—to preserve their own interests—have emerged as opponents of the nuclear projects advocated by a pronuclear group, composed of the Second Ministry of Machine Building (nuclear matters) and the Guangdong Province electric power bureau, as well as elements of the CAS. Because of the dire need for energy in China, we anticipate that the pronuclear group will prevail. Any test of force, however, appears to have been postponed by economic readjustment.

25X1

One of the most serious technical problems the Chinese face in any attempt to develop a viable nuclear power program is obtaining a reliable source of enriched uranium fuel. (Although unlikely, the Chinese could purchase or develop CANDU-type reactors, which use natural uranium fuel.) Without purchase or development of a nuclear fuel cycle package that includes uranium enrichment capacity, the Chinese would be forced to sign long-term contracts with foreign suppliers for most, if not all, of the enriched uranium fuel they need. China does not have sufficient enrichment capacity to support a substantial nuclear power program without reducing its military weapons programs. Indications are that China might rely initially on foreign-supplied enriched uranium but would expand its own enrichment capabilities as soon as possible to eliminate its foreign dependence.

25X1

25X1

To develop a domestic nuclear power industry, China will have to rely on appreciable quantities of imported technology and adaptation of skills and expertise acquired through its nuclear weapons program. Such a transfer could save a significant amount of time and resources. Chinese officials have stated that they have already shifted several thousand technical personnel from their nuclear weapons programs to their nuclear power program.

25X1

25X1
25X1

But technology specifically related to power reactors—such as design and component manufacturing, as well as special fuel fabrication, materials testing, and instrumentation—would have to be developed.

[redacted]

From what is known of their research for developing their own nuclear power reactors, the Chinese apparently tend to favor a pressurized-water technology. Although some groups are investigating CANDU-type heavy water reactors and high-temperature, gas-cooled reactors, the emphasis to date has been on pressurized-water technology. This tendency is substantiated by the greater Chinese interest in pressurized-water types when evaluating foreign reactors. Also, the known Chinese naval propulsion systems use pressurized water. [redacted]

[redacted]

[redacted] Chinese research on power reactors ranges from five to 20 years behind the United States, depending on the area of research. We believe that China will not develop a commercial nuclear-power reactor for at least 10 years. Research has been carried out on fuel-cycle calculations, fuel assemblies, irradiation of fuels and materials, and core designs for pressurized-water reactors. But we do not know how complete this research has been. The Chinese acknowledge problems with fabricating reactor pressure vessels and with welding cladding materials, as well as with the technology for primary coolant pumps. [redacted]

The Chinese have the technical capacity to develop power reactors, but they have a pronounced lack of nuclear technicians as a result of the Cultural Revolution. They also lack skilled craftsmen, such as welders, electricians, and pipefitters. And they are equally deficient in the large, rolling mills needed for making pressure vessels, heat-exchange equipment, and large steam generators. Whether selected purchases of foreign equipment and technology, plus the expertise gathered from technicians and delegations 25X1 sent abroad to absorb foreign technology, can close this 20-year gap in 10 years remains to be seen. [redacted] 25X1

If the Chinese see a need to go full speed ahead on nuclear weapons development, their nuclear power program will experience some disruption, because the required technical personnel are the same for both efforts. The likelihood and extent of such a disruption are dependent upon China's willingness to push forward with both programs simultaneously. Indications are, however, that development of nuclear power is subordinate to the continued development of strategic 25X1 weapons. Such a disruption is probable, therefore, because the Chinese have said adamantly that nuclear 25X1 weapons development comes before domestic power needs. [redacted] 25X1

Energy Conservation

Fully aware of their severe energy problems, the Chinese recently have introduced numerous measures and incentives to promote energy conservation within their industrial sector. In December 1980, Premier Zhao Zhiyang admitted that energy shortfalls have caused Chinese industry to run at only 70 percent capacity. Through the public media, including a variety of national and local campaigns, Chinese 25X1 energy officials have encouraged the adoption of more efficient energy use. Conservation plans for 1980-81 call for saving 23 million tons of coal, 3 million tons of gasoline and diesel fuel, 1.5 million tons of fuel oil and coke, and 7 million megawatts of electricity. Special-energy commissions have been set up in Guangdong and Shanghai to implement policies of energy conservation. In view of the existing shortage of funds and the restrictions on large-scale capital construction, localities are being encouraged to exploit more fully alternative sources of energy, such as biogas, geothermal sources, and wood fuel. Budgets for research into 25X1 conservation-related technologies have been increased. China's ability to meet the energy needs of its industrial and agrarian sector will be greatly dependent upon the success of these conservation measures.
[redacted] 25X1

Chemical Industry

The technical level of China's chemical industry—which provides critical materials for agriculture, heavy industry, light industry, and textiles—consists of a thin veneer of advanced imported technology, layered on a base of small-scale, out-of-date processes. As shown by substantial chemical imports and purchases of whole plants in the 1970s, the industry is not meeting the country's needs in quality, quantity, or variety of chemical products. Supplies of basic chemicals for heavy industry probably have kept pace with industrial needs, but other crucial areas such as fertilizer and petrochemicals have lagged behind demand. Petrochemicals, of course, have been dependent upon the development of China's oil industry, which only began in earnest in the 1960s and recently has had growth-related problems. 25X1

As part of its modernization drive, Beijing is firmly committed to a policy of importing from the West advanced technology for the chemical industry. Such technology importation is hardly a new policy for China. Several Western petrochemical plants were imported in the mid-1960s, and about $1.6 billion worth of petrochemical facilities were purchased from 1972 to 1976. An ammonia/urea plant brought from Western Europe in the 1960s was adapted and copied, and became the basis for medium-size fertilizer plants. The difference today is the scale of imports—contracts for over $3 billion in chemical plants have been signed since 1977, with continued priority given to fertilizers and petrochemicals. China almost certainly will attempt to copy the technology in these plants. Most recently, however, imports of whole petrochemical plants and major investments for construction of large-scale petrochemical facilities have been curtailed as a result of cutbacks in heavy industry and capital construction. 25X1

Large-scale effort is under way to solve some of the technology absorption problems that became obvious during the import program in the mid-1970s. In order to boost the woefully inadequate number of people technically qualified to build, to operate, and ultimately, to duplicate these plants, China is rejuvenating technical education, reopening research institutes, and sending increasing numbers of technicians overseas for study at universities, laboratories, and chemical factories. The Chinese have indicated a greater willingnness to allow foreign technicians to participate in various projects to facilitate technology assimilation. 25X1

Although China is a major producer of chemical fertilizer, more than half its production from small, inefficient plants is poor quality. In 1973-74, Beijing contracted for 13 ammonia/urea complexes from abroad. But these plants are only now beginning to operate, because their construction was delayed by a variety of problems, ranging from a lack of skilled workers to shortages of natural gas feedstock. China needs additional capacity for fertilizers containing nitrogen, phosphorus, and potassium and is seeking foreign technology for triple superphosphate and compound fertilizers. 25X1

China has sought foreign technology for all phases of the petrochemical process—from feedstocks to products. Emphasis has been given to synthetic fiber production—vinylon, nylon, and acrylics—to free land from natural fiber production, to boost domestic textile production, and to increase exports. The Chinese also are attempting to increase production capacity for basic plastics and synthetic rubber. To produce these, they need large-scale production technologies for basic feedstocks, such as ethylene. In addition, the Chinese need to ensure that an adequate supply of petroleum is available to produce sufficient feedstocks for efficient plant operation. A lack of petroleum-based inputs was a contributing factor in the cancellation or postponement of numerous petrochemical projects in 1979-80. 25X1

Production of industrial chemicals—currently from small, outdated facilities—will have to be expanded to keep pace with planned industrial growth. This will require modern technologies, such as ion exchange processes for chlorine and caustic soda. These substances now are produced with 1960s technologies. Technology absorption problems, raw material shortages (particularly petroleum because of competing fuel demands), and infrastructural weaknesses will continue to plague these plans. 25X1

Metallurgy

The Chinese have continued to increase the quantity and quality of a wide range of steels—including carbon steel, high-strength steels, tool steel, spring steel, and some stainless steels. They cannot produce, however, the quantity, variety, and in some cases, quality of steels to meet their needs. The most critical technical shortcomings in the metallurgical industry are in the manufacturing process, including poor quality control, limited standardization, and insufficient instrumentation. Electric power shortages also have prevented some plants from effectively using what modern manufacturing equipment they have, such as induction furnaces, electroslag refining cells, and electron beam welding. [redacted]

The Chinese have had several significant technological successes in metallurgy. They have acquired and employed important ablative graphite composite technology with critical applications in the manufacture of missile reentry vehicles. This technology is applicable to rocket motor cases, certain wing panels, and other components for fighter aircraft structures. Another significant achievement is the application of ceramic coatings for improving heat resistance of metal components in gas turbines: the Chinese have used the ceramic coatings as the matrix for a filamentary composite by the inclusion of quartz fibers or metal screens. [redacted]

To upgrade the quality and quantity of their steels and to learn advanced Western steel technology, the Chinese contracted with the West Germans and Japanese in the mid-1970s to build the Wuhan steel plant and in 1978, for a large steel complex at Baoshan. Technical bottlenecks, lack of sufficient electricity, and funding problems have slowed progress of these projects. [redacted]

Consistent with their policy of gaining self-sufficiency and faced with a scarcity of chromium, the Chinese have developed on their own a steel alloy of tungsten, silicon, and manganese for use in bearings. The alloy is good quality, but it is not equal to American state-of-the-art chromium alloys because Chinese processing techniques are inferior to those in the West. To counter a similar lack of nickel, the Chinese have developed nonnickel steels. Although they have fabricated refractory metals, available evidence indicates the quality is not up to that of advanced, industrialized nations. The Chinese have concentrated on molybdenum alloy development, because they probably are following early Soviet developments and because molybdenum is plentiful in China. [redacted] 25X1

25X1

[redacted]

25X1

Before economic readjustment slowed their negotiations, the Chinese had expressed interest in obtaining foreign facilities to process aluminum, aluminum powder, cobalt, duralumin, magnesium, nickel, tungsten, and titanium. That they used these technologies to develop modern weapons has been readily acknowledged by the Chinese: aluminum for aircraft and missiles, aluminum powder for solid-propellant missiles, cobalt for jet engine manufacture, duralumin for airframes, magnesium for aircraft components, nickel for aircraft engine alloys, tungsten for armor piercing shells, and titanium for high-temperature airframes and engine shrouds, as well as the electroslag technology for armor plate. Assuming that they will continue to acquire foreign technologies, we anticipate that the Chinese first will pursue the technologies for dual-use systems and tactical weapons. In weapons development programs, China seems to be committed to completing existing strategic programs and to developing replacements for obsolete conventional weapons systems. [redacted]

25X1

25X1

25X1

China is working to develop further its ceramics technologies for commercial and military applications. Chinese laboratories have successfully manufactured cubic boron nitride, a ceramic material used for cutting tools; the Chinese should be able to produce enough of this material to supply cutting tool producers within their machine tool industry. Another significant advance was the laboratory-scale fabrication in 1979 of silicon nitride for use as wear- and corrosion-resistant coatings for gas turbines.

The Chinese also are actively pursuing many research efforts in composite materials development. The bulk of that research, however, is devoted to the simplest of the three types—filamentary composites. Serious research on sandwich and multilayer composites is being deferred for the present. The Chinese can produce some of the high-purity metals required for the matrix part of various filamentary composites, but only on a small scale in the laboratory; the Chinese encounter quality control problems when they try to produce some of the high-performance metal matrix materials on an industrial scale. One problem, for example, occurs in the production of cast-steel superalloy matrix materials; the thermal resistance and stress properties of these materials have been uneven.

The Chinese also have generally encountered problems in their attempts to produce the long fibers and filaments used in filamentary composites. Although they have made notable advances in creating some laboratory specimens, they lack the expertise to manufacture uniform, full-scale filaments. Because they cannot produce some filaments on even a laboratory scale, they are actively seeking foreign technologies to manufacture aluminum, silicon, and carbon fibers.

Machine Tool Industry

The Chinese have developed a substantial machine tool industry, capable of supplying China's low- and medium-grade machine tool needs. China has exported some good-quality, durable, general-purpose machine tools to southeast Asia. The Chinese are far less capable, however, of making precision machine tools and such things as miniature ball bearings and the high-speed reduction gears required to produce certain weapons. Levels of numerically controlled machine tool technology are as much as 10 years behind Western technology. Further, even if the Chinese acquired advanced numerical control machine technology from abroad, problems would arise from the impact on employment and from the uneven technological match of the imported equipment with the managerial system and the equipment already in various Chinese facilities. 25X1

25X1

China's machine toolmakers have been handicapped by deficiencies in design capability and lack of precision standards, as well as their lack of understanding of automated production controls. Quality control procedures are almost nonexistent. Computer-aided design of parts, components, and assembled mechanisms was virtually unknown until very recently. Computer-aided manufacturing is only in an early stage of development. 25X1

China's machine-building industry produces serial items, using assimilated Western and Soviet technologies of the 1940s and 1950s, but it has not yet absorbed the newer technologies—such as multiaxis and numerically controlled machines—acquired through one-of-a-kind or small lot purchases from Japan and the West in the 1960s and early 1970s. 25X1

During the 1970s, the Chinese revealed some very sophisticated Chinese-made machine tools, including indigenous designs of numerically controlled systems, using integrated circuits. These precision tools, however, are one-of-a-kind prototypes and are not expected to result in increased manufacturing capability and capacity until the mid-to-late 1980s. 25X1

25X1

To meet the current needs of its aerospace industry, China has contracted to purchase from West Germany, Japan, and the United States such specialized equipment as five-axis machine tools, numerically controlled milling machines, hot isostatic presses, vacuum technology and equipment, and assembly line equipment for airframe production. These acquisitions, however, will have to be accompanied by improvements in management and production organization before they have a major impact on overall productivity. 25X1

Communications

General goals for telecommunications modernization were set at China's second national conference of postal and telecommunications departments in August 1977: to implement modern telecommunications service in each of China's more than 2,000 counties by 1980, to upgrade or to replace manual and semiautomatic step-by-step switching systems with automatic electromechanical crossbar or all-electric switching technologies by 1985, and to catch up with the state of the art of the advanced world by the year 2000. [redacted]

The Chinese cannot meet these broad, vague, and ambitious goals. Possibly by the year 2000 they will be doing world state-of-the-art research in one or more areas of telecommunications technology and will have some services roughly equivalent to those in the most advanced countries. But they will not achieve world level across the board for all communications technologies. [redacted]

Efforts are being made in a wide range of communications areas—facsimile, color television, satellites, fiber optics, computers, and data transmittal—down to replacement of hand-cranked telephones and manual switching with dial telephones and automatic switching. But current levels of Chinese telecommunications technology, quantities of equipment, and caliber of services are—at best—minimally adequate to meet the needs of high-priority defense and the civil government. For example, the complete conversion to automatic switching in each of China's 2,000 counties by 1985 is impossible because of the sheer magnitude of the tasks. The Chinese now realize that their original goals were too ambitious. Since the economic adjustment process began in mid-1979, they have not spoken of these objectives. [redacted]

Direct broadcasting via satellite is an area in which the Chinese could make significant advances by the year 2000. The Chinese space program [redacted] is no more than 10 years behind Western communications satellites. The characteristics of communications satellites—high technology but low-volume production and testing that can be done on the ground—mean that real achievements can be made by a relatively small number of experts, which is precisely the Chinese situation. [redacted]

The other areas in which the Chinese could achieve their goals are fiber optics and facsimile technology. The Chinese have great interest and need in these areas and could make appreciable progress by the year 2000, if investments in training and research budgets are not cut back significantly. [redacted] 25X1

If the Chinese are to advance in their telecommunications technology, they must overcome some serious problems. The most serious appear to be the lack of a sufficient number of trained scientists and engineers 25X1 and the lack of an infrastructure that can provide test and manufacturing equipment, mass production facilities, and spare parts. The majority of China's research and development facilities in telecommunications seem more like prototype laboratories than the Western concept of research and development centers. The Chinese facilities focus on producing new equipment, but they also are forced to do most of the ancillary development of machine tools, parts, and 25X1 test equipment. This detracts from the efficiency of more advanced personnel and limits resources that can be devoted to manufacturing the end product. Further, the lack of more than rudimentary standards and directions from centralized authorities and the heavy dependence on local initiative and self-reliance make the Chinese telecommunications network a patchwork quilt of varying levels of technology. Serious problems with the interconnectability of equipment and the quality and reliability of the network are inevitable and can be seen everywhere in China's telecommunications systems. [redacted] 25X1

Before economic readjustment halted negotiations, the Chinese were looking abroad for technological assistance. Between 1978 and 1979 China cooperated with France and West Germany to receive training on 25X1 the Symphonie A satellite. The Chinese made no purchase, however. Although the Chinese had discussed purchase of a US communications satellite, they informed the United States in late 1980 that they 25X1 were postponing acquisition of a satellite. The Chinese 25X1 have sent many delegations abroad for international meetings and factory tours associated with negotiations for foreign equipment. In these negotiations, the Chinese have strived to obtain maximum exposure to advanced design and manufacturing technology, as opposed to making outright equipment purchases.

25X1

Their efforts have focused mainly on the areas of satellite communications and automatic switching systems, both of which continue to be the highest priorities, as the Chinese have excess microwave and cable capacities.

Electronics

China lags 10 to 15 years behind the West in computer technology and the manufacture of associated semiconductor component technology (microelectronics). The rate of progress in various aspects of computer and semiconductor technologies has differed considerably, however. For example, Chinese accomplishments in developing large-scale scientific computers for scientific applications have been impressive, while efforts in the development of software and modern peripheral equipment for general-purpose use remain at primitive levels. In semiconductor technology, laboratory research has yielded impressive developments, but production yields of standardized products have been very disappointing.

Aside from their late start in this rapidly evolving industry, the Chinese have faced a number of technical and nontechnical obstacles. The very highly decentralized structure of the industry and the lack of concern or understanding of the computer user are probably the most important problems. The absence of a supporting parts-and-materials infrastructure creates important technical and manufacturing problems. The limited number of skilled personnel, especially technically oriented policy officials and middle managers, is also a very serious problem.

The impact of computers on the broad range of China's modernization goals is constrained, because the Chinese application of computers is limited. Computers are used in science and engineering in only a relatively few, high-priority cases—for example, a railroad, a steel mill, or a power grid. To make a real contribution to modernization, computers will have to be put into general use for planning, coordinating, and evaluating in areas such as agriculture, energy development, manufacturing, and transportation.

For widespread application, computers must become available in quantity and must be designed for general use. Given the Chinese drive for self-sufficiency, this will mean domestic mass production of computers (as opposed to importation), for which production standards must be established. The Chinese have a program to produce one series of general-purpose computers, but they have not enforced equipment and 25X1 quality standards evenly. A lack of coordination and control, moreover, will impede widespread use of this or any other series of computers. We anticipate that it will be at least 10 to 15 years before an indigenous Chinese computer industry can begin to satisfy domestic needs. 25X1

Microelectronics. The state of the art of microelectronics technology in China lags that of the West by more than 10 years. If volume production is taken into account, the gap is even wider. Most Chinese integrated circuits—the primary components of most electronic systems—produced in quantity are small- and medium-scale bipolar and metal-oxide semiconductor devices. These compare with models produced in the United States in the 1960s. But the quality of many of the Chinese components and in turn, their 25X1 reliability, are uneven. Probably the most sophisticated device in production is a 256-bit random-access memory circuit. 25X1

The Chinese have announced the development of impressive one-of-a-kind devices on a laboratory basis: for example, 1,000- and 4,000-bit semiconductor memories and high-speed, bipolar memory devices of 256 bits. These devices, however, appear to be a long way from volume production. The breadth of semiconductor research at universities and research institutes is impressive, but it provides very little assist- 25X1 ance in solving the major production problems facing the Chinese semiconductor industry, because links are still inadequate between university research efforts and production-oriented organizations. 25X1

The Chinese are following the same basic path for developing silicon integrated circuits as that of the United States. They have the advantage, however, of seeing which technologies are more viable in the West and thus are able to emphasize the appropriate technologies more quickly. The Chinese are stepping up 25X1 their efforts to acquire Western semiconductor technology, specifically production equipment. But production expertise—acquired through purchase of

complete production facilities and extended contact with Western production operations and personnel—will be needed to solve many processing problems quickly.

The major shortcomings of semiconductor processing technology in China are (1) shortages of contemporary fabrication equipment, (2) lack of modern production facilities with necessary environmental control, and (3) inability to control process quality and to enforce production standards. Chinese production suffers from the very low yields of reliable devices and the wide variations in device characteristics. The major cause of low yield is contamination of devices during manufacture by environmental impurities and handling. These problems can be resolved only through the installation of better clean-room facilities and strict adherence to clean-room production practices. As the Chinese attempt higher device complexities, these problems will multiply if they are not corrected.

Processing control, through a thorough understanding of processing phenomena and causes of defects, is necessary to produce semiconductor devices of good, uniform quality. To a large extent, this understanding can come with experience, but good production practices and understanding first must be transferred to the many plants producing semiconductors. Enforcing device standards and monitoring production operations are important means for stimulating this transfer of expertise.

Whether the Chinese can move to higher levels of integration in semiconductor devices will depend directly upon Chinese abilities to solve these production problems. In addition, more advanced processes for design, fabrication, and testing of devices will have to be developed or acquired if the Chinese are to manufacture medium- and large-scale integrated circuits successfully. Although the Chinese have already shown strong interest in computer-aided design and automated testing technology, these areas probably will not be critical until the Chinese reach large-scale-integration levels of density. Efforts are already under way to develop capabilities in advanced technologies of lithography, ion implantation, and other processing that will become important in the future. In the near term, however, improvement of existing production processes and equipment is the most pressing priority in Chinese microelectronics technology. 25X1

25X1

Computer Technology. The computer situation is much the same as that of the United States in the 1950s—a small installed base of a few thousand machines: predominantly digital computers, but with a high percentage of analog and hybrid computers performing vital functions, a large variety of computers that are not generally compatible (no one model having been made in quantity). The focus is on applications in scientific and industrial control rather than in business. Because the leading specialists in the computer field in China are academic—not industrial—personnel, they are more interested in the technology than in the manufacturability, quality, and usability of computer products. 25X1

25X1

The Chinese have a firm understanding of the fundamentals of computer hardware design and are knowledgeable about most of the latest Western design innovations. They have shown strong capabilities in fairly sophisticated adaptations of Western designs, choosing features that best meet Chinese needs and making modifications to compensate for limitations in their electronic component technology. The Chinese do not always make the correct design choice, however, to meet application needs of users or to develop a computer that can be easily manufactured in quantity. For example, we believe that a high percentage of the new machines developed by CAS institutes do not meet these two requirements and thus are not put into production. 25X1

25X1

The Chinese apparently do not have a strong fundamental capability in software design, particularly in areas important for developing large operating systems. While they have made respectable accomplishments in developing compilers for several high-level programing languages, their progress in understanding concepts important in the design of complex software systems is very limited. This is due partly to their limited base of software specialists and their historically narrow focus on scientific and engineering applications, involving highly trained computer professionals, knowledgeable in machine or assembly-language programing. Only a conscious shift to

general-purpose computing with a commitment of significant resources to software development and manufacture of electromechanical equipment will improve this situation. Still to emerge is an emphasis on the widespread use of general-purpose computers, programed and operated by large numbers of users with little formal computer training. [redacted]

Only within the last few years have the Chinese had a program to produce a series of compatible computers of varying size, with interchangeable components, to serve a wide variety of general-purpose users. The DJS-200 computer series, patterned after the IBM 360 series, is a major step in this direction. But Chinese attempts to build DJS-200 computers at different locations, using locally available parts and materials, probably will lead to serious variations in product quality and major problems of compatibility, even among the same models within the series. [redacted]

The Chinese computer designers intend to replace the 200 series with a new general-purpose computer series, the DJS-300, which will be compatible with Western computer systems and equipment. Its development, however, will be influenced by some of the same problems that have affected other Chinese computer development programs. [redacted]

A State Administration of Computer Industry has been formed to enforce conformity with equipment-interface standards, to develop important operating systems software, and to provide nationwide customer support. So far, this organization has had only limited success. Failure to meet such responsibilities will greatly reduce and delay effective and widespread use of the DJS-200 or any other series of computers. [redacted]

In addition to lagging the West in developing stand-alone computer products, China has very little experience in the use or design of complex systems involving multiple, interconnected computers or major computer centers with a large assortment of remote terminals and mass storage. Modest development efforts have been under way in building time-shared systems, but the Chinese lack the expertise required for integrating facilities, equipment, communications, and systems. The same deficiencies exist in software and peripherals, and understanding users' needs. [redacted]

Visitors to China often are impressed by the diversity of advanced research projects and by the up-to-date technical awareness of Chinese computer scientists, whose research efforts in the most advanced areas of computer technology give the impression that the Chinese are further ahead than they actually are. In fact, very few, if any, of these research projects have made any real impact on computer use, because the concepts are too advanced to be applied. [redacted]

25X1
25X1

Surrounded by a vast amount of Western technology and expertise, the Chinese have made gallant efforts to adapt or to reverse-engineer Western products and designs. For example, some series of minicomputers for specific functions are patterned after exploited US minicomputers, specifically US Data General Nova models. A large-scale, general-purpose computer was designed in China, based on early design and other engineering documentation in Western open literature. Even when the Chinese successfully adapt Western computer design concepts, however, we doubt that the Chinese understand why or how such designs were created. To understand user requirements and to design a highly serviceable product of adequate manufacturability cannot be learned from merely reverse-engineering of foreign manufactured equipment; direct involvement in the design process is required. [redacted]

25X1
25X1

Space

Since its space program began in the late 1950s, China has orbited eight satellites, the first in 1970. [redacted]

25X1
25X1

Formed in 1968, the Chinese Academy of Space Technology in the Seventh Ministry of Machine Building is responsible for developing and producing satellites and space launch vehicles. In addition to launch facilities, the Chinese have constructed a large, space-tracking network with sites throughout the country [redacted]

25X1
25X1
25X1
25X1
25X1

Satellites. China made impressive progress early in its space program, apparently because of the high priority placed on the role of space during the mid-1970s when the development of military intelligence satellites was emphasized. The general problems of mass production that commonly plague most other Chinese industries are not a factor in the space program, because most related items are custom made in very limited quantities. Recently, however, the space program appears to have been delayed, possibly because of a combination of funding, bureaucratic, and technical problems.

Most Chinese space technologies are not state of the art but appear adequate for present needs. We expect the space program to improve with China's exposure to more advanced foreign technologies. We do not expect technological levels and assimilation of more sophisticated skills to pose the greatest obstacles—at least in the near term. We see lack of understanding of the concepts of systems and subsystems reliability, lack of rigorous quality control, and poor systems integration and program management as the major obstacles to the Chinese space program.

China's planned domestic program will provide a modest experimental satellite communications system but not the fully operational system desired. To achieve this and to speed up progress in their own space program, the Chinese negotiated for the purchase of direct-broadcast satellites from the United States or Europe, hoping to absorb as much satellite technology as possible. Early in 1981, however, the Chinese officially informed the United States that the purchase would have to be delayed for several years due to lack of funds. In the meantime, China apparently plans to improve its domestic communications by leasing channels on Intelsat satellites, which China has used for international communications for several years. 25X1

China also has a strong interest in earth resources satellites. A domestically built satellite is under development, but in the meantime, the imagery from US Landsats is being used in a variety of programs. To facilitate receipt of Landsat-produced data, the Chinese have negotiated for several years to buy a Landsat ground station. This purchase has been delayed for financial and technical reasons. The Chinese have expressed a desire to separate the receiving portion of the station from the data processing section. This would not only increase the price of the station, but because the separation would entail additional strategic technology, the sale would require further review by COCOM, a coordinating committee of representatives from NATO countries. 25X1

25X1

25X1

Appendix

The Structure and Operation of China's S&T System [redacted] 25X1

The Chinese leadership has attempted to revitalize and to strengthen the organizations responsible for managing S&T policy and for conducting R&D activities. Scientists and technical personnel have been given a large voice in policymaking. The functioning of China's S&T system, however, has been plagued by organizational and political problems, some of which stem from the continued aftereffects of the Cultural Revolution, but most of which have been characteristic of complex organizations in China. The cumbersome bureaucratic apparatus for handling S&T affairs has been beset by coordination problems at both the administrative and working levels. [redacted]

The prerequisites for S&T modernization, therefore, have included not only a need to elevate the status of S&T in China but also to confront the large number of inefficiencies within the S&T sector that limit sustained productivity. Initial indications are that economic benefits have been marginal, and numerous bureaucratic obstacles still restrict the development of an effective, indigenous S&T system. [redacted]

Research in China is conducted within three main institutional structures: the CAS, the various industrial and machine-building ministries, and the university system. In addition, there is a defense-related research system, which often penetrates the civilian research structure. Most basic scientific research is conducted within the institutes of the academy, while most applied research is carried out in ministry institutes. Some research is also conducted in Chinese universities, although their primary function is education. The research activities of these three structures are monitored and integrated by national S&T commissions. [redacted]

Chinese S&T Commissions

Two national commissions are responsible for overseeing S&T activities in China. The SSTC coordinates and administers civilian-related S&T programs. The National Defense Science and Technology Commission (NDSTC) has primary responsibility for administering S&T policy for defense-related S&T projects. [redacted] 25X1

Established in 1958, the SSTC was disbanded during the Cultural Revolution. Its reestablishment in 1977-78 with associated provincial committees reflected China's increased emphasis on the role of science, as well as an effort to upgrade the status and to expand the role of experts in the formulation of S&T policies at both the national and provincial levels. [redacted] 25X1 25X1

As currently organized, the state commission reports directly to the State Council, which ultimately controls the commission budget and has final approval over all major commission-endorsed projects. According to pronouncements by the Chinese political and scientific leadership, the commission has been delegated a key policymaking responsibility. Its present role in policy formulation probably is much more limited, however, than these statements indicate. In 25X1 general, we believe, the main function of the commission is to give coherence and to foster cooperation in the implementation of national policy for science and technology. [redacted] 25X1

The SSTC has five bureaus, each with a specific function. The first bureau makes plans for overall research efforts, while the second bureau has responsibility for projects in energy, resources, and materials. The third bureau oversees S&T activities related to transportation, communications, industry, and the development of new technologies. The fourth handles agriculture, health, and light industry, and the fifth is responsible for developing nuclear energy. An admin- 25X1 istrative office supports China's international S&T relationships and facilitates coordination and communication among S&T groups in China. In each province, an S&T committee coordinates provincial activities with the SSTC at the national level [redacted] 25X1

The primary concern of the SSTC is research for civilian applications. A major responsibility is seeing that research results are distributed to production units and coordinating projects that cut across the various production ministries. Each SSTC bureau has members from universities, the CAS, and the industrial and machine-building ministries. An example of the broad SSTC involvement in both research and development was a conference the commission called recently to speed up the development and manufacture of large-scale-integration (LSI) computer components in China. The conference was attended by academicians, technicians, engineers, and scientists representing research institutes, ministerial production units, and machine-building ministries.

The SSTC also is responsible for helping to support Chinese contacts with foreign scientists and S&T organizations. Commission policy encourages and facilitates scientific collaboration with other nations in support of national development.

The NDSTC is the chief coordinating body for defense-related S&T activities. In contrast to the SSTC, the NDSTC appears to have a direct control over many of the institutes and factories with which it carries out its mandate. It also appears to be much more authoritative than the SSTC and apparently is involved in the technical aspects as well as the administrative side of research. The NDSTC has greater discretionary control over funding and a higher priority to utilize nondefense organizations and personnel for cooperation on specific projects. It may directly task any university laboratory or industrial ministry, including those outside its direct administrative control. (Note: The SSTC does not appear to have the ability to task NDSTC institutes, although it may request assistance on certain occasions.) The NDSTC also has a much larger budget than the SSTC and seems to have first priority when new graduates are assigned and new equipment is allocated. Some attempt has been made to bring all S&T research, civilian and defense, under the control of the SSTC, but the degree to which this has been successful remains unclear. Although the NDSTC clearly plays a major role in China's S&T system, the full extent of its capabilities remains vague, due apparently to Chinese efforts to disguise defense-related research from the view of Western observers.

Chinese Academy of Science

The CAS, headquartered in Beijing, is the most prestigious Chinese scientific organization and the central institution in China responsible for carrying out basic S&T research. Although the CAS is supposed to report to the SSTC, it has become semiautonomous in many respects and often reports directly to the State Council. Its growing influence derives from the fact that most of China's best S&T personnel work within institutes of the science academy.[1] In addition, the science academy has sole responsibility for the administration and functioning of all its own research institutes and facilities. 25X1

25X1

The CAS has five major departments: (1) mathematics and physics, (2) chemistry, (3) biosciences, (4) geosciences, and (5) technical sciences. Decision-making authority is centered in the presidium of the scientific council of the academy. The presidium is composed of 29 members; two-thirds are members of the academy, and one-third are representatives of other government and party institutions. The presidium elects the president and vice president of the academy. The CAS has approximately 117 research institutes scattered under the control of 11 branch academies in the cities of Shanghai, Hefei, Chengdu, Kanjing, Kumming, Guangzhou, Shenyang, Wuhan, Lanzhou, Xingiang, and Xian. The institutes are oriented mainly toward research in basic and theoretical sciences. The CAS also plays a role in S&T training and education, because it holds responsibilities for the administration of four S&T universities—in Hefei, Harbin, Zhejiang, and Chengdu. 25X1

25X1

25X1

25X1

Approved For Release 2007/08/08 : CIA-RDP83B00551R000200150005-7

The Chinese Machine-Building and Industrial Ministries

Machine-Building Ministries	Areas of S&T Responsibility
First	Civilian products (for example, machinery, metals, light industrial equipment)
Second	Nuclear energy and weapons
Third	Aerodynamic systems
Fourth	Electronics and computers
Fifth	Conventional weapons and munitions
Sixth	Shipbuilding
Seventh	Ballistic missiles/space
Eighth	Tactical cruise missiles

Selected Industrial Ministries
Ministry of Chemical Industry
Ministry of Coal Industry
Ministry of Light Industry
Ministry of Metallurgical Industry
Ministry of Petroleum Industry
Ministry of Textile Industry

[redacted]

Industrial and Machine-Building Ministries
The second major organizational sector for S&T research in China includes the industrial and machine-building ministries, a number of which have S&T departments at the national level. Most have one or more research institutes that, in turn, supervise varying numbers of research components. Also under the ministries are production facilities, some of which have their own research facilities. [redacted]

Ministerial research institutes mainly conduct applied research that tends to be closely related to production goals at the national level. S&T activities within this sector and budgetary allocations for research generally fall under the jurisdiction of the individual ministries. Depending upon the scope of a project or its civilian/military orientation, the two commissions—the NDSTC and the SSTC—have the authority to task the various ministries. [redacted]

Universities
A third source of S&T research in China is its universities. The CAS, the industrial and machine-building ministries, and the Ministry of Education all have universities that they control and fund. Both basic and applied research are done at the universities; as expected, those with close ties to industrial ministries focus on applied research, while the science academy universities emphasize basic research. All these universities also may do research in industrial or defense-related fields. Efforts are under way to expand significantly the research function of Chinese universities. Among the leading universities with strong S&T programs are Qinghua, Fudan, and Beijing; these are administered by the Ministry of Education. [redacted] 25X1

The CAS universities have already been noted. Examples of ministry universities are the 10 controlled by the Ministry of Metallurgical Industry; these are specifically oriented toward metallurgical studies and research. The Third Machine-Building Ministry controls the Northwestern Technical University in Xian, which specializes in aeronautical engineering. These ministerial universities also are responsible for training S&T personnel for their parent ministries. Other universities are run entirely by the Ministry of Education or jointly by the ministry and the industrial or machine-building industry. [redacted]

25X1

25X1

Planning
First announced in 1978 by the central political leadership, the Chinese National Science Plan was based upon the recommendations and advice of leading scientists throughout China. During the current readjustment program, it has undergone major review and revision as a result of shifting priorities and the party leadership's better recognition of immediate needs. The major emphasis now is on applied research and the direct contributions that S&T can make to the modernization program. [redacted]

25X1

25X1

The Chinese National Science Plan provides guidelines for determining the priorities of S&T activities. It outlines basic objectives for the development of specific research plans by each research institution. Based upon these objectives, every research department within each CAS institute, for example, annually reviews its accomplishments of the previous year,

25X1

surveys the progress of continuing programs, examines proposals for each new research project, and then composes a departmental plan for the following year. The managerial staff of the research institute—with the advice of an academic committee of outside experts and some of its own scientists—reviews the departmental plans and proposes an institute-wide plan. A CAS committee of senior managers reviews these institute plans and, theoretically at least, forwards a proposed plan for the entire academy through the state S&T commission to the state council. [redacted]

New S&T projects within Chinese research institutes may be proposed by individual scientists or technicians or by industrial managers. A good deal of input appears to come from below. Once a national research program is completed, the staff of the SSTC identifies gaps and recommends specific institutes to conduct research to fill these gaps. Guidance could concern research given a high priority in the national plan but not fully covered in institute plans, or it could provide for further development of prototypes and products that are not quite ready for mass production. [redacted]

Initial plans for reform of the S&T system were aimed at decentralizing decisionmaking and increasing the autonomy of each operating unit, but these plans have been postponed as readjustment has necessitated greater central control to advance the economy and S&T system. For S&T, this has meant a more careful monitoring of all related activities and greater attention to the ways in which research can make a contribution to the modernization program. At the same time, scientists have been given an increased role in policy formulation to assess proposed projects or foreign technology purchases for technical and economic feasibility. The emergence of "techno-economics" as a growing field of study in China reflects the awareness of the leadership to further minimize waste and to ensure optimal use of scarce S&T resources. [redacted]

In theory, research organizations submit yearly research proposals and plans to the State S&T Commission, which then reviews and balances the requests in accordance with annual and longer range plans. The CAS is an exception. It has enormous prestige and a much longer institutional history than the SSTC. Prior to formation of the commission and its predecessor, the science academy was responsible for all national S&T planning. The CAS apparently submits its research plans directly to the State Ccouncil for approval, without going through the State S&T Commission, except for obtaining tacit approval. This bypass was facilitated by Vice Premier Fang Yi: he is Minister in Charge of State S&T Commission and until May 1981 was president of the science academy. His coinciding appointments may have been designed to alleviate potential problems with coordination and 25X1
competition between the two organizations. Further, the State Council, not the SSTC, approves the opening of new academy branch institutes and approves new members elected to the academy. Most recently, the freedom of the CAS to follow an independent line of action may be more limited due to the closer monitoring of S&T activities by the SSTC and economic officials. [redacted] 25X1

When different institutes propose similar projects, the CAS (if the competing proposals are presented by different science academy institutes) or the SSTC (if 25X1
the competing proposals are developed by ministerial institutes) is responsible for assigning the project to the appropriate institute. Such decisions usually are based on the scientific record and geographical location of the institutes, the relative costs of the proposals, and the completion schedule proposed. Although research historically has been concentrated in Beijing and Shanghai, and institutes in the two cities generally have had better facilities and more competent personnel, an attempt has been made recently to disperse research funds and to strengthen local S&T capabilities throughout other areas. [redacted] 25X1

The locus of decisionmaking generally varies with the priority and level of funding required for a particular project. For example, construction of the recently postponed Beijing proton synchroton project entailed the participation of more than 10 ministries, commissions, and other units, as well as more than 100 25X1
factories. The entire project had an estimated price tag of US $500 million. It received authorization from the Politburo and the State Council, and was approved directly by Deng Xiaoping. [redacted] 25X1

On the other hand, CAS institutes, military institutes, and universities all have some discretionary funds that they can dispense without higher authorization. Decisions on institutional support and funding for small projects often are based upon the guidance and advice of participants from the lower levels of these organizations. In addition, each Vice Premier at the State Council reportedly controls his own scientific research funds and can allocate them as desired without any other approval. Within the Chinese S&T system, organizations that have control over funding tend to have control over the assignment of S&T priorities and R&D activities.

Coordination

A major function of the SSTC is coordinating research efforts between the ministerial and CAS institutes. In addition to eliminating duplication of projects, this function involves encouraging cooperation among institutes, stimulating the flow of S&T information from abroad to relevant institutes, and ensuring that new processes and inventions are available to potential users. The goal of all these activities is effectively and efficiently translating research developments into production results.

The Chinese S&T system frequently is plagued by a lack of coordination between research institutes, lack of communications between scientists, duplication of research efforts, and only limited interactions between research institutes and factories. End-user involvement in the choice of S&T projects and in the evaluation of R&D results is often conspicuously absent. Chinese R&D efforts tend to be highly compartmentalized. As a result, little communication and interaction take place among the science academies, the ministries, and the university research groups, or even among parts of the same organizations. One result is that the way the system will function or how innovations will develop and spread cannot always be logically predicted.

The SSTC was reestablished to alleviate such problems. A closer look at recent examples of R&D projects in progress or completed reveals that individuals and groups from diverse organizations have begun to work together to improve the quality of technology and related products. CAS research institutes have worked with universities and factories under the Ministry of Education to develop products. The military has become increasingly associated with academy institutes to conduct applied research in several areas. In a growing number of cases, ministerial research institutes and universities are working closely with factories to solve manufacturing problems or to develop new products; ministries are selecting CAS research developments to put into production; and the science academy is selling its research designs directly to factories on a contract basis. In short, stronger connections are being established among elements within the S&T system and between S&T organizations and production units. 25X1 25X1

The Chinese bureaucracy, however, remains cumbersome, and the S&T system frequently falls victim to an overburdensome bureaucracy. The chain of command in the research structure tends to be painfully slow and tedious, and formal communications between structures still appear to have problems. Through a variety of personal ties and informal channels, Chinese scientists manage to link an assortment of organizations drawn from any of the three research structures, the military, or the factories into working units on specific projects. How widespread 25X1 and how often this practice occurs, how long it takes, and the percentage of time such linking can be done successfully remain open to question. Because of this uncertainty, managers in production enterprises have difficulty in incorporating technology developments into their planning strategy. 25X1

Despite recent improvements, such as the emergence of various organizations responsible for the collection and dissemination of scientific information, links among components of the S&T system for diffusing technical information remain weak or do not exist. Western scientists frequently have reported that scientists in one region were duplicating research efforts being carried out in another area. Foreigners often have been the first to tell Chinese scientists 25X1 about their counterparts' work. 25X1

25X1

This acknowledged unevenness in coordination and cooperation appears to result from several factors. The narrow professional training of the scientists educated in the Soviet Union during the 1950s or in China itself since 1949 makes it difficult for scientists even in related fields to communicate with one another. Moreover, scientists working on defense-related items often are segregated from those working on civilian projects; they are admonished not to discuss their work with other scientists. Geographical factors also enter into the picture. Substantial distances between urban areas and the lack of adequate and rapid communication links limit cooperation among scientists.

Many research institutes may be apprehensive about volunteering the services of their personnel in cooperative projects for fear that the personnel might not return. Securing a qualified replacement is difficult, particularly if the research institute is not in a major urban area.

Frequently, organizational and personal relationships have resulted in animosity and competition. Because of the paucity of equipment, personnel, and funding, institutes tend to compete for resources rather than to cooperate. This problem was exacerbated during the initial period of decentralization in 1978-79, because possession of specialized information and expertise became a valuable technical resource with potential financial rewards.

To counter some of these problems, the SSTC instituted several policies: Professional S&T associations have been reestablished and charged with facilitating communication among scientists and technicians through national and local level conferences, and publication and dissemination of professional journals. S&T associations have been encouraged to provide advice and guidance to research and production units in their vicinity. The state commission has actively encouraged greater interaction among S&T personnel and has sponsored several national conferences on particularly important topics. Although the tangible benefits of these efforts remain limited, it is too early to evaluate their long-term implications for S&T modernization.

Supervision

The SSTC provides minimal supervision over the actual research within both ministerial and CAS institutes. The state commission has the authority, however, to monitor the work of the institutes through several mechanisms: periodic progress reports submitted by the institutes on research projects and meetings between institute personnel and commission officials for planning purposes. The lack of technical expertise among a sizable number of commission personnel and the loyalty of commission scientific advisers to their respective institutes probably impact upon the objectivity and quality of commission reviews. In the long run, an institute that fails to fulfill its annual plans appears likely to have its share of research funds reduced, particularly as the readjustment program acquires momentum. The commission has been especially anxious to alleviate the frequent waste from purchasing foreign technologies that later were underutilized due to a dearth of competent persons to use the technology or a lack of understanding of maintenance procedures. As a result, all proposals for major purchases of foreign technology now must be reviewed and approved by the central authorities in Beijing responsible for foreign technology acquisition.